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CHRONOLOGY OF EDUCATION

Zhejiang University, Hangzhou, B.S. Geology, Feb. 1982.

Zhejiang Agricultural University, Hangzhou, M.S. Soil Physics, July 1986.

University of Arizona, Tucson, Ph.D., Soil, Water, and Environmental Sciences/Hydrology, Dec. 1995.

EMPLOYMENT

09/2012-present Geological Research Scientist, Energy Geosciences Division (formerly Earth Science Division), Lawrence Berkeley National Laboratory

10/2004-09/2012 Sr. Scientific Engr. Assoc., Earth Science Division, Lawrence Berkeley National Laboratory

12/1997-10/2004 Geological Scientist, Earth Science Division, Lawrence Berkeley National Laboratory

01/1996-12/1997 Postdoctoral Fellow, Department of Soil & Environmental Sciences, UC Riverside

01/1992-12/1995 Research Associate, Department of Soil & Water Science, University of Arizona, Tucson

08/1986-12/1991 Assistant Research Scientist, Institute of Mountainous Disaster and Environment, Chinese Academy of Science, Chengdu

02/1982-07/1983 Faculty (Teaching Assistant), Department of Hydraulic Engineering, Tianjin University, Tianjin

HONORS AND AWARD

2016 Director's Award for Exceptional Societal Impact Achievement, Lawrence Berkeley National Laboratory

2012 Director's Award for Exceptional Tech Transfer Achievement, Lawrence Berkeley National Laboratory

The Secretary's Achievement Award, United States Dept. of Energy, 2011.

Award of (Youth) Excellent Paper, Science & Technology Association of Sichuan Province, 1988.

PUBLICATIONS

Peer Reviewed Journal

1. Pan, L., Spycher, N., Doughty, C. and Pruess, K. (2016), ECO2N V2.0: A TOUGH2 fluid property module for modeling CO₂-H₂O-NACL systems to elevated temperatures of up to 300°C. *Greenhouse Gas Sci Technol.* doi:10.1002/ghg.1617.
2. Guo, C., L. Pan, K. Zhang, C. M. Oldenburg, C. Li, and Y. Li (2016), Comparison of compressed air energy storage process in aquifers and caverns based on the Huntorf CAES plant, *APPLIED ENERGY*, 181, 342-356, DOI: 10.1016/j.apenergy.2016.08.105.
3. Liu, H., Q. He, A. Borgia, L. Pan, and C. M. Oldenburg (2016), Thermodynamic analysis of a compressed carbon dioxide energy storage system using two saline aquifers at different depths as storage reservoirs, *ENERGY CONVERSION AND MANAGEMENT*, 127, 149-159, DOI: 10.1016/j.enconman.2016.08.096.
4. Zhang, Y., C. M. Oldenburg, and L. Pan (2016), Fast estimation of dense gas dispersion from multiple continuous CO₂ surface leakage sources for risk assessment, *INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL*, 49, 323-329, DOI: 10.1016/j.ijggc.2016.03.002.
5. Peiffer, Loïc, C. Wanner, and L. Pan, Numerical modeling of cold magmatic CO₂ flux measurements for the exploration of hidden geothermal systems. *Journal of Geophysical Research: Solid Earth*, DOI: 10.1002/2015JB012258, 2015.
6. L Pan, B Freifeld, C Doughty, S Zakem, M Sheu, B Cutright, T Terrall (2015). Fully coupled wellbore-reservoir modeling of geothermal heat extraction using CO₂ as the working fluid. *Geothermics* 53, 100-113. doi:10.1016/j.geothermics.2014.05.005.
7. Reagan, M.T., G.J. Moridis, J.N. Johnson, L. Pan, C.M. Freeman, K.L. Boyle, N.D. Keen and J. Husebo, (2015) Field-Scale Simulation of Production from Oceanic Gas Hydrate Deposits, Transport In Porous Media, *Transp Porous Med* (2015) 108:151–169. DOI 10.1007/s11242-014-0330-7.
8. Kristina Rasmussen, Chin-Fu Tsang, Yvonne Tsang, Maria Rasmussen, Lehua Pan, Fritjof Fagerlund, Jacob Bensabat andAuli Niemi. (2014) Distribution of injected CO₂ in a stratified saline reservoir accounting for coupled wellbore-reservoir flow. *Greenhouse Gas Sci Technol.* 1–18 (2014); DOI: 10.1002/ghg.
9. Weng, Huan-Xin, Hui-Ping Liu, De-Wang Li, Mingli Ye, Lehua Pan, Tian-Hong Xia (2014), An innovative approach for iodine supplementation using iodine-rich phytogenic food. *Environmental Geochemistry and Health.* 02/2014; DOI:10.1007/s10653-014-9597-4.

10. Pan, Lehua, and Curtis M Oldenburg (2014) T2Well—An integrated wellbore-reservoir simulator. *Computers & Geosciences* 65 (2014) 46–55, available online 29 June 2013, <http://www.sciencedirect.com/science/article/pii/S0098300413001696>).
11. Finsterle Stefan, Yingqi Zhang, Lehua Pan, Patrick Dobson, Ken Oglesby (2013). Microhole arrays for improved heat mining from enhanced geothermal systems. *Geothermics* 47 (2013) 104–115.
12. Oldenburg, Curtis M., and Lehua Pan (2013) Utilization of CO₂ as cushion gas for porous media compressed air energy storage. *Greenhouse Gas Sci Technol.* 3:1–12 (2013); DOI: 10.1002/ghg.
13. Oldenburg, Curtis M., and Lehua Pan (2013) Porous Media Compressed-Air Energy Storage (PM-CAES): Theory and Simulation of the Coupled Wellbore–Reservoir System. *Transp. Porous Med;* DOI 10.1007/s11242-012-0118-6.
14. Andrea Borgia, Karsten Pruess, Timothy J. Kneafsey, Curtis M. Oldenburg, Lehua Pan (2012), Numerical simulation of salt precipitation in the fractures of a CO₂-enhanced geothermal system *Geothermics* 44 (2012) 13– 22.
15. Litang Hu, Lehua Pan, Keni Zhang (2012), Modeling brine leakage to shallow aquifer through an open wellbore using T2WELL/ECO2N. *International Journal of Greenhouse Gas Control* 9 (2012) 393–401.
16. Pan, Lehua, Curtis M. Oldenburg, and Karsten Pruess, Yu-Shu Wu (2011), Transient CO₂ leakage and injection in wellbore-reservoir systems for geologic carbon sequestration. *Greenhouse Gas Sci Technol.* 1:335–350 (2011); DOI: 10.1002/ghg.
17. Pan, Lehua, Stephen W. Webb, and Curtis M. Oldenburg (2011), Analytical solution for two-phase flow in a wellbore using the drift-flux model. *Advances in Water Resources.* 34 (2011) 1656–1665. doi:10.1016/j.advwatres.2011.08.009.
18. Ma, Xue-wen, Huan-xin Weng, Min-hua Su and Lehua Pan, 2011. Drying sewage sludge using flue gas from power plants in China. *Environmental Earth Sciences*, DOI: 10.1007/s12665-011-1166-x.
19. Oldenburg, C. M., B. M. Freifeld, K. Pruess, L. Pan, S. Finsterle, and G. J. Moridis (2012), Numerical simulations of the Macondo well blowout reveal strong control of oil flow by reservoir permeability and exsolution of gas, *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*, 109(50), 20254-20259, DOI: 10.1073/pnas.1105165108.
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21. Curtis M. Oldenburg, Jennifer L. Lewicki, Lehua Pan, Laura Dobeck and Lee Spangler, 2010. Origin of the patchy emission pattern at the ZERT CO₂ release test. *Environmental Earth Sciences*, 60(2):241-250, DOI: 10.1007/s12665-009-0442-5.
22. Weng, Huan-Xin, Ai-Lan Yan, Chun-Lai Hong, Ya-Chao Qin, Lehua Pan and Ling-Li Xie, 2009. Biogeochemical transfer and dynamics of iodine in a soil–plant system. *Environmental Geochemistry and Health,* 31(3): 401-411, DOI: 10.1007/s10653-008-9193-6.

23. Lehua Pan, Jennifer L. Lewicki, Curtis M. Oldenburg, Marc L. Fischer, 2009. Time-Windows-Based Filtering Method for Near-Surface Detection of Leakage from Geologic Carbon Sequestration Sites. *Environmental Earth Sciences*. 60:359-369, DOI 10.1007/s12665-09-0436-3.
24. Lewicki, J. L., G. E. Hilley, M. L. Fischer, L. Pan, C. M. Oldenburg, L. Dobeck, and L. Spangler. 2009. Eddy covariance observations of surface leakage during shallow subsurface CO₂ releases, *J. Geophys. Res.*, 114, D12302, doi:10.1029/2008JD011297.
25. Pan, L., J. Jin, N. Miller, Y.-S. Wu, and Gudmundur Bodvarsson, 2008. Modeling Hydraulic Responses to Meteorological Force: from Canopy to Aquifer. *Vadose Zone Journal*, 7:325-331. LBNL-61018.
26. Finsterle S., C. Doughty, M.B. Kowalsky, G.J. Moridis, L. Pan, T. Xu, Y. Zhang, and K. Pruess, 2008, Advanced Vadose Zone Simulation Using TOUGH. *Vadose Zone Journal* 7:601-609.
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29. Zhang, K., Wu, Y.-S. and Pan, L., 2006. Temporal Damping Effect of the Yucca Mountain Fractured Unsaturated Rock on Transient Infiltration Pulses, *Journal of Hydrology*. LBNL-57539. 327 (1-2) 235-248.
30. Wu, Y.-S., and L. Pan. 2005. An Analytical Solution for Transient Unsaturated Radial Flow through fractured Porous Media. *Water Resources Research*, 41, W02029, doi:10.1029/2004WR003107. (LBNL-54587).
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32. Wu, Y.-S., L. Pan, and K. Pruess, 2004. A Physically Based Approach for Modeling Multiphase Fracture-Matrix Interaction in Fractured Porous Media. *Advances in Water Resources* 27:875-887. (LBNL- 54749).
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34. Wu, Y.-S., and L. Pan, 2003, Special relative permeability functions with analytical solutions for transient flow into unsaturated rock matrix. *Water Resources Research*, 39(4):1104-1029. LBNL-50443.
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37. Wu, Yu-Shu; Pan, Lehua; Zhang, Winnie; Bodvarsson, Gudmundur S. 2002. Characterization of flow and transport processes within the unsaturated zone of Yucca Mountain, Nevada, under current and future climates. *J. of Contaminant Hydrology* 54:215-247. (LBNL-46572).
38. Liu, H.H., Bodvarsson, G.S., and Pan, L. 2002. Reply. *Water Resources Research*, 38(11), published 2003, LBNL-49008.
39. Liu, H.H., G.S. Bodvarsson, and L. Pan, Determination of particle transfer probability in random walk algorithms for fractured porous media, *Water Resources Research*, 36 (3), pp. 707-713, 2000.
40. Wu, L., L. Pan, J. Mitchell, and B. Sanden, Measuring Saturated Hydraulic Conductivity using a generalized solution for Single-Ring Infiltrometers, *Soil Science Society of America Journal*, 63, pp. 788-792, 1999.
41. Pan, L., and L. Wu. 1998. A hybrid global optimization method for inverse estimation of hydraulic parameters: Annealing-simplex method. *Water Resource Research*. 34(9):2261-2269.
42. Pan, L., and P. J. Wierenga. 1997. Improving numerical modeling of 2-D water flow in variably saturated and heterogenous porous media. *Soil Science Society of America Journal*. 61(2):335-346.
43. Pan, L., A.W. Warrick, and P.J. Wierenga. 1997. Downward water flow through sloping layers in the vadose zone: Time-dependence and effect of slope length. *Journal of Hydrology*. 199:36-52.
44. Wu, L., L. Pan, M. Roberson, and P.J. Shouse. 1997. Numerical evaluation of ring-infiltrometers under various soil conditions. *Soil Sci.* 162:771-777.
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50. Dan, L. and L. Pan. 1992. Adsorption characteristics of phosphorus to calcareous purple soils and a bi-mechanism model. *Mountainous Region Research*, Vol.5(4).
51. Li, Z. and L. Pan. 1991. Pathways of sustained and stable development of agriculture in Southwest China. *Soft Sciences*. 1991-03.
52. Li, Z. and L. Pan. 1991. On sustainable agriculture development in Southwest China. *Journal of Soil Science and Agrochemistry*, 6(1-2):1-4.

53. Pan, L. and J. Yu. 1990. In-situ estimation of dynamical distribution of solute in perched soils – A Kalman filter approach. Journal of Southwest China Agricultural University, Special issue of the national soil physics symposium.
54. Pan, L. 1990. Spectral analysis method to estimate the apparent thermal diffusivity of soil. Journal of Southwest China Agricultural University, Special issue of the national soil physics symposium.
55. He, Y., F. Zhang, L. Pan, and A. Bang. 1990. Research on the degradation of purple soils in hilly area of Sichuan Basin: I. Physical properties of purple soils and characteristics of its degradations. Resource Exploitation and Protection, 6(1):3-7.
56. He, Y., L. Pan, and A. Bang. 1990. Research on the degradation of purple soils in hilly area of Sichuan Basin: II. Micromorphology of purple soils and characteristics of its degradations. Resource Exploitation and Protection, 6(2):67-70.
57. Pan, L. 1989. The position and direction of agricultural development in Guizhou Province, China. Regional Economy Research, 1989-2:21-25.
58. Pan, L. and J. Yu. 1988. Systematically modeling the movement of NO_3^- in perched soils. (Chinese) Soil Science 19(3):100-103.
59. Pan, L. 1988. Dynamical analysis and prediction of grain production in Yunnan province, China – A time series model. Journal of Soil Science and Agrochemistry, 3(3-4):85-90.
60. He, Y., X. Zhao, L. Tian, and L. Pan. 1987. Mineral composition of purple soils and its effects on soil fertility. Journal of Soil Science and Agrochemistry, 2(1-2):44-46.
61. Pan, L. 1987. Systematic analysis and development strategy of agriculture –Principles and methodology. Journal of Soil Science and Agrochemistry, 2(1-2):151-154.

Chapters, Proceedings, and Reports:

Pan, L., and C.M. Oldenburg (2016) TOGA: A TOUGH code for modeling three-phase, multi-component, and non-isothermal processes involved in CO_2 -based Enhanced Oil Recovery, Lawrence Berkeley National Laboratory Report LBNL-1006472.

Lehua Pan, Christine Doughty, Barry Freifeld, Curtis M. Oldenburg (2015). Modeling a CO_2 thermosiphon in a partially saturated reservoir using T2Well with EOS7CMA. PROCEEDINGS, TOUGH Symposium 2015 Lawrence Berkeley National Laboratory, Berkeley, California, September 28-30, 2015.

Ester Maria Vasini, Alfredo Battistelli, Paolo Berry, Stefano Bonduà, Villiam Bortolotti, Carlo Cormio, Lehua Pan (2015). Interpretation of production tests in geothermal wells with T2Well-EWASG. PROCEEDINGS, TOUGH Symposium 2015 Lawrence Berkeley National Laboratory, Berkeley, California, September 28-30, 2015.

Andrea Borgia, Curtis M. Oldenburg, Rui Zhang, Lehua Pan, Stefan Finsterle, T.S. Ramakrishnan (2015). Simulations of CO₂ push-pull in fractures to enhance geophysical contrast for characterizing EGS sites. PROCEEDINGS, TOUGH Symposium 2015 Lawrence Berkeley National Laboratory, Berkeley, California, September 28-30, 2015.

Oldenburg, C. M., and L. Pan (2014), Simulations of porous media compressed air energy storage (PM-CAES) with CO₂ as cushion gas, ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY, 248.

Lehua Pan and Curtis M. Oldenburg, Chapter 15. Rigorous process simulation of compressed air energy storage (CAES) in porous media systems, in Computational Models for CO₂ Geo-sequestration & Compressed Air Energy Storage Edited by Rafid Al-Khoury Jochen Bundschuh, CRC Press 2014, Pages 479–498, Print ISBN: 978-1-138-01520-3, eBook ISBN: 978-1-315-77872-3, 2014.

Freifeld, B., S. Zakim, L. Pan, B. Cutright, M. Sheu, C. Doughty, and T. Held (2013), Geothermal energy production coupled with CCS: a field demonstration at the SECARB Cranfield Site, Cranfield, Mississippi, USA, GHGT-11, 37, 6595-6603, DOI: 10.1016/j.egypro.2013.06.592.

Lehua Pan, Curtis M. Oldenburg (2012), T2Well—An Integrated Wellbore-Reservoir Simulator. PROCEEDINGS, TOUGH Symposium 2012 Lawrence Berkeley National Laboratory, Berkeley, California, September 17-19, 2012.

Yingqi Zhang, Lehua Pan, Patrick Dobson, Ken Oglesby, Stefan Finsterle (2012), Simulating Microhole-Based Heat Mining from Enhanced Geothermal System. PROCEEDINGS, TOUGH Symposium 2012 Lawrence Berkeley National Laboratory, Berkeley, California, September 17-19, 2012.

Matthew T. Reagan, George J. Moridis, Katie L. Boyle, C. Matthew Freeman, Lehua Pan, Noel D. Keen, Jarle Husebo (2012). Massively Parallel Simulation of Production from Field-Scale Oceanic Gas Hydrate Deposits. PROCEEDINGS, TOUGH Symposium 2012 Lawrence Berkeley National Laboratory, Berkeley, California, September 17-19, 2012.

Yingqi Zhang, Lehua Pan, Patrick Dobson, Ken Oglesby, and Stefan Finsterle (2012) Initial Evaluation of Microholes for Improved Heat Extraction from EGS Reservoirs. GRC 2012 Annual Meeting.

Yingqi Zhang, Lehua Pan, Patrick Dobson, Ken Oglesby, and Stefan Finsterle (2012) Microholes for Improved heat extraction from EGS Reservoirs: Numerical Evaluation. PROCEEDINGS, Thirty-Seventh Workshop on Geothermal Reservoir Engineering Stanford University, Stanford, California, January 30 - February 1, 2012. SGP-TR-194

Jonny Rutqvist, Hui-Hai Liu, Donald W. Vasco, Lehua Pan, Karl Kappler, Ernie Majer, 2011. Coupled non-isothermal, multiphase fluid flow, and geomechanical modeling of ground surface deformations and potential for induced micro-seismicity at the In Salah CO₂ storage operation. Energy Procedia 4: 3542-3549.

Pan, L., Yu-Shu Wu, Curtis M. Oldenburg, and Karsten Pruess, 2011. T2Well/ECO2N Version 1.0: Multiphase and Non-Isothermal Model for Coupled Wellbore-Reservoir Flow of Carbon Dioxide and Variable Salinity Water. LBNL-4291E.

Quanlin Zhou, Stefan Finsterle, Lehua Pan and Yingqi Zhang, 2010. Mobility of Tritium in Engineered and Earth Materials at the NuMI Facility, Fermilab. LBNL Report.

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Jennifer L. Lewickia, George E. Hilley, Marc L. Fischer, Lehua Pan, Curtis M. Oldenburg, Laura Dobeck, Lee Spangler, 2009. Detection of CO₂ leakage by eddy covariance during the ZERT project's CO₂ release experiments. Energy Procedia 1(1):2301-2306.

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Pan, L. and Y. Seal, 2007. Geothermal evolution of geothermal aquifer and the potential effects of geothermal heat pumping. Technical report.

Pan, L., 2006., CLMT2 user's guide: A Coupled Model for Simulation of Hydraulic Processes from Canopy to Aquifer, Version 1.0. Technical Report (LBNL-60857). Lawrence Berkeley National Laboratory, July 2006.

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Pan, L., 2004, Analysis of Hydrologic Properties Data, ANL-NBS-HS_0000 42 REV 00, SBC, Las Vegas, Nevada. LBID-2525

Pan, L., K. Zhang, Y.S. Wu, and G.S. Bodvarsson, 2004. Percolation through heterogeneous fractured porous media under transient infiltration: Reconciling measured and predicted seepage into a mined opening. The 68th Annual Meeting for Soil Science Society of America, Seattle, Washington, Oct. 31-Nov. 4, 2004. Agronomy Abstracts. American Society of Agronomy. Madison. WI.

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Wu, Y.S. and Pan L., 2004. Analytical solutions for transient flow through unsaturated fractured porous media, Proceedings of the Second International Symposium on Dynamics of Fluids in Fractured Rocks, Edited by B. Faybishenko and P. A. Witherspoon, Lawrence Berkeley National laboratory, University of Californian, Berkeley, Californian, USA, 360-366, February 10-12. (LBNL-)

Wu, Y.-S., Lu, G., Zhang, K., Pan, L., and Bodvarsson, G. S. 2003. Analyzing flow patterns in unsaturated fractured rock of Yucca Mountain using an integrated modeling approach. LBNL-54006.

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Pan, L., H.H. Liu, M. Cushey, and G.S. Bodvarsson, 2001. DCPT: A new random walk particle tracker for dual-continua, LBNL-42958, Lawrence Berkeley National Laboratory, Calif., 2001.

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Pan, L., and P. J. Wierenga, 1996. Globally optimized estimator of hydraulic properties based on upward infiltration data. Wenstern Soil Physics Annual Meeting. Las Vagas, NV, January 1996.

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Pan, L. 1995. Techniques for improving numerical modeling of water flow in variably saturated, heterogenous media. Ph.D. Dissertation. The University of Arizona.

Pan L., and P. J. Wierenga, 1995. An efficient and simple solver to Richards' equation. Western Soil Physics Annual Meeting. Las Vegas, NV, January 8-11, 1995.

Pan L., and P. J. Wierenga, 1994. An efficient algorithm to solve Richards' equation for variably saturated soils(2D). The 86th Annual Meeting for Soil Science Society of America. Seattle, Washington, November 13-18.

Dan, L., and L. Pan. 1992. Phosphorus in calcareous purple soils: II adsorption characteristics. Proceedings of the 4th national conference of young soil scientists, Page 183-188. Beijing Agriculture University Press.

Li, Z., L. Pan, and Y. Li, 1990, Agricultural development and strategy of Southwest China. Academic Press, Beijing.

Pan, L., 1990, Chapter 10. Temporal and spatial variations of the temperature in purple soils. In Purple Soils in China (edited by Li et al.), Chinese Academic Press, Beijing.

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Pan, L., and J. Yu, 1986. Modeling solute transport and transformation in rice soils. The 1st national conference of young scientists, Nanjing.

Pan, L., and J. Yu, 1985. The observability and the controllability of soil-solute system. The 3rd national conference of soil physics. Shanghai.

Softwares:

TOGA V1.0 – A compositional reservoir simulator of nonisothermal, three-phase (oil, gas, aqueous), multi-components flow

ECO2N V2.0 – three components (CO₂, Water, NaCl) EOS module for TOUGH2 (up to 300°C)

T2Well/ECO2N V1.0 – a coupled wellbore-reservoir simulator of nonisothermal, two phase, CO₂-Brine flow

T2Well/EOS3 (beta) – a coupled wellbore-reservoir simulator of nonisothermal, two phase, Air-Water flow

T2Well/Eoil3 (beta) – a coupled wellbore-reservoir simulator of nonisothermal, two phase, Gas-oil flow

T2Well/EOS1 (beta) – a coupled wellbore-reservoir simulator of nonisothermal, two phase, one component (H₂O) flow

T2Well/EOS7cma (beta) – a coupled wellbore-reservoir simulator of nonisothermal, two phase, 5 components flow

T2Well/ECO2H (beta) – a coupled wellbore-reservoir simulator of nonisothermal, two phase, CO₂ -Brine flow (T beyond 110 C)

CLMT2/ CO₂ (beta) – a coupled land surface-subsurface model with capability to simulating net CO₂ flux from a terrestrial ecosystem as response to climate change, groundwater variations, and land management practices

WinGridder Version 1.0, 2.0, & 3.0 – A visual grid generator for control volume based numerical simulators

DCPT Version 1.0, 2.0, & 3.0 – Dual-continuum particle tracker

SimAnneal Version 1.0 – A global optimization program for inverse parameter estimation based on Annealing-Simplex method

Cylinder Version 1.0 – Unsaturated flow and transport simulator for lab column

CLMT2 V1.0 – A Coupled surface-subsurface hydraulic model

ToolBox of some analytical solutions – Java codes for several analytical solutions of water flow and transport problem through (fractured) porous media.